Executive Summary

This executive summary provides an overview of the interplant connection facilities planning analysis project. It discusses the multiple objectives of the project and the importance of the interplant connection toward achieving the goals of the Indianapolis Combined Sewer Overflow (CSO) Long-Term Control Plan (LTCP). It also describes the methodologies used during the analysis and presents the results and conclusions.

The recommended concept for the interplant connection consists of a 144-inch-diameter interceptor that would originate near CSO 117 (east of the Belmont plant on the other side of White River). It would terminate near the headworks of the Southport facility. Initially the interceptor would store and convey CSO captured from Structure 117. After the Fall Creek-White River deep tunnel system is constructed, the new interceptor would convey the CSO captured in the tunnel. Captured CSO from the deep tunnel would be treated at the Southport facility via expanded, upgraded and new equipment.

The Southport facility should be expanded to enable a peak hourly flowrate of 425 MGD through conventional primary treatment and, after flow equalization, should provide a peak treatment capacity of 375 MGD through the rest of the facility. The 375-MGD peak capacity represents a 225-MGD increase over the current peak capacity of 150 MGD. Of the 375 MGD total, 300 MGD would receive biological treatment and the remaining 75 MGD would be treated by enhanced high rate clarification (EHRC) or its equivalent. The design flow criteria include a 75 MGD contingency dependent on results from a more rigorous analysis of the maximum dewatering rate needed for the deep tunnel.

Project Background

The City of Indianapolis Department of Public Works (DPW) provides wastewater treatment and conveyance services to communities in Marion County and portions of surrounding counties. Wastewater is treated at two advanced wastewater treatment (AWT) facilities that discharge into the White River: the Belmont facility and the Southport facility.

Most of the combined sewer collection system interceptors are directed to the Belmont facility, which therefore receives the largest portion of wastewater flow surges during wet weather. Although flows directed to the Southport facility are primarily from separate sanitary sewers, a portion of the combined sewage flow from the Belmont service area is conveyed to the Southport facility via the Belmont-Tibbs Interceptor and the Southwest Diversion Interceptor. The Southwest Diversion Interceptor allows flexibility in balancing the normal dry weather flows between the two facilities. It also helps to ensure that the aggregate capacity of the two facilities is maximized during wet weather before CSOs occur in the collection system and at the facilities.

The Southwest Diversion Interceptor has no reserve capacity for conveying the relatively large volumes of CSO that will be captured system-wide by upcoming improvements to the collection system. One objective of this project was to develop a facilities plan for a new interplant connection that will convey all or part of the system-wide captured CSO to the Southport facility for treatment. A second objective was to develop and evaluate various concepts for expanding the Southport facility to provide effective treatment of the captured CSO.

Existing Collection System and LTCP Improvements

Figure ES.1 shows the basic components of the Indianapolis wastewater collection and treatment facilities: the two AWT facilities, their respective service areas, and the interplant connection that enables part of the wastewater from the Belmont service area to be treated at the Southport facility. The dashed arrows in this figure represent the overflows that occur during wet weather from (1) CSO outfalls throughout the combined sewer areas in the Belmont service area, (2) CSOs of raw sewage at the headworks of the two AWT facilities, and (3) primary effluent bypasses at the two AWT facilities.

In the early 1980s, when construction of the city's AWT facilities was nearing completion, a concept for a new interplant connection was developed. DPW contracted with MD Wessler & Associates, Inc. (Wessler) to prepare recommendations for the interplant connection between the Belmont and Southport facilities. In November 1982, Wessler submitted its report to DPW.

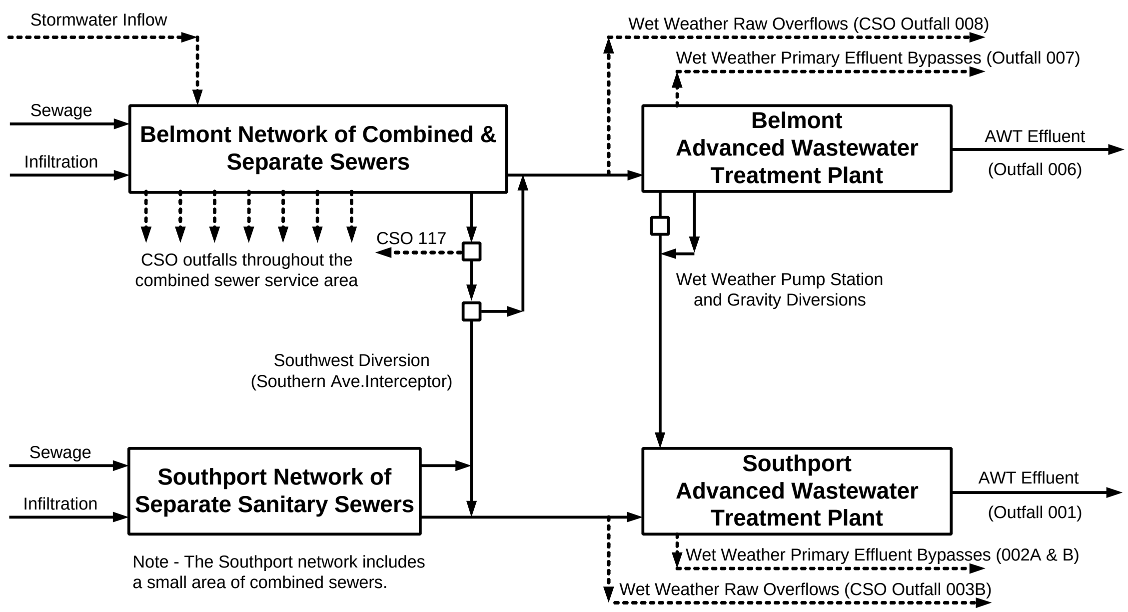


Figure ES.1
Schematic of Existing Collection and Treatment Facilities

The Wessler report described a plan to construct a 68 million-gallon-per-day (MGD) sewer line that would intercept wet weather surges of flow from various incoming lines at the Belmont headworks for gravity conveyance to the Southport facility. Although the line was not constructed, the Wessler report established that capturing and distributing part of the CSO load to the Southport facility was vital. Accordingly, the 2001 draft of the LTCP retained provisions for a new interplant connection (CDM, Greeley and Hansen, and others, 2001a).

CDM (2002) made a system analysis of the CSO abatement concepts proposed in the 2001 draft LTCP. Of particular interest was the treatment rate and on-site storage volume that would be needed at the Belmont facility to accommodate the additional sewage from the "bleed-back" of the captured CSO.

The LTCP is currently being modified so as not to impose additional wet weather flow surges on the Belmont facility. In the modified draft, the Fall Creek tunnel for capturing CSOs along Fall Creek would be extended to include a White River section for capturing the CSOs along White River. This combined storage and conveyance tunnel system (known as the deep tunnel) could terminate at a point east of the Belmont facility near the existing Southwest Diversion Structure and CSO 117.

The facilities planning analysis also included how the city has accounted for future growth within the service areas.

Objectives and Methodology

The interplant connection facilities planning analysis had three areas of study:

- Develop and evaluate alternative concepts for the new interplant connection consistent with the draft LTCP.
- Develop a proposed interplant connection route.
- Evaluate alternative treatment processes at the Southport facility for accommodating additional wet weather flows and loads.

To accomplish these objectives, the project team used the following methodology:

- Developed computer models to perform an analysis of the current system and then evaluate the various alternatives for the interplant connection.
- Analyzed dry weather flows and loads on the two AWT facilities and estimated future dry weather flows.
- Developed alternative concepts for the interplant connection and performed cost analyses of each alternative.
- Developed the proposed routing of the interplant connection and associated profile drawings to aid in further assessing project feasibility and estimating construction costs.
- Analyzed current treatment processes at the Southport AWT facility.
- Evaluated alternative treatment processes at the Southport AWT facility for accommodating the additional wet weather flows and loads conveyed by the new interplant connection.

Computer Model Development and Application

Figure ES.2 illustrates the general framework of the CSO LTCP variant assumed at the onset of this project. At the heart of this plan is a deep tunnel for capturing CSOs and a new interplant connection for conveying the captured CSO. The design criteria for the interplant connection as well as new wet weather treatment facilities will depend on the size and dewatering flow pattern from the deep tunnel, which will in turn depend on the extent to which CSOs are captured after various improvements are made to the collection system.

Given the complexity of this overall system, the project team used several computer models to simulate the performance of several key building blocks:

- A 5-year NetSTORM model that simulated how the LTCP components for capturing CSO would have performed had they been in operation from 1996 through 2000.
- A newly developed deep tunnel model that provided preliminary analyses of the various tunnel dewatering rates and volumes for various scenarios. The input flow data to the tunnel model came from the captured CSO output flow data generated by the 5-year NetSTORM model.
- The integrated tunnel model was used to (1) evaluate the feasibility of a new aboveground equalization basin near CSO 117 (known as EQ Basin 117) and (2) assess the workability of splitting the captured CSO between the two AWT facilities.
- Updated versions of the Belmont and Southport “treatment rate vs. storage volume” models. These were used to examine how additional flow from captured CSO and future growth within the service areas would affect headworks pumping capacities, on-site storage volumes and treatment rates needed to achieve specific wet weather overflow frequencies at the AWT facilities.

- The detailed Stormwater Management Model (SWMM) to more fully explore the facility planning objectives. SWMM was also used for continuous simulation of a "representative year" of precipitation data.

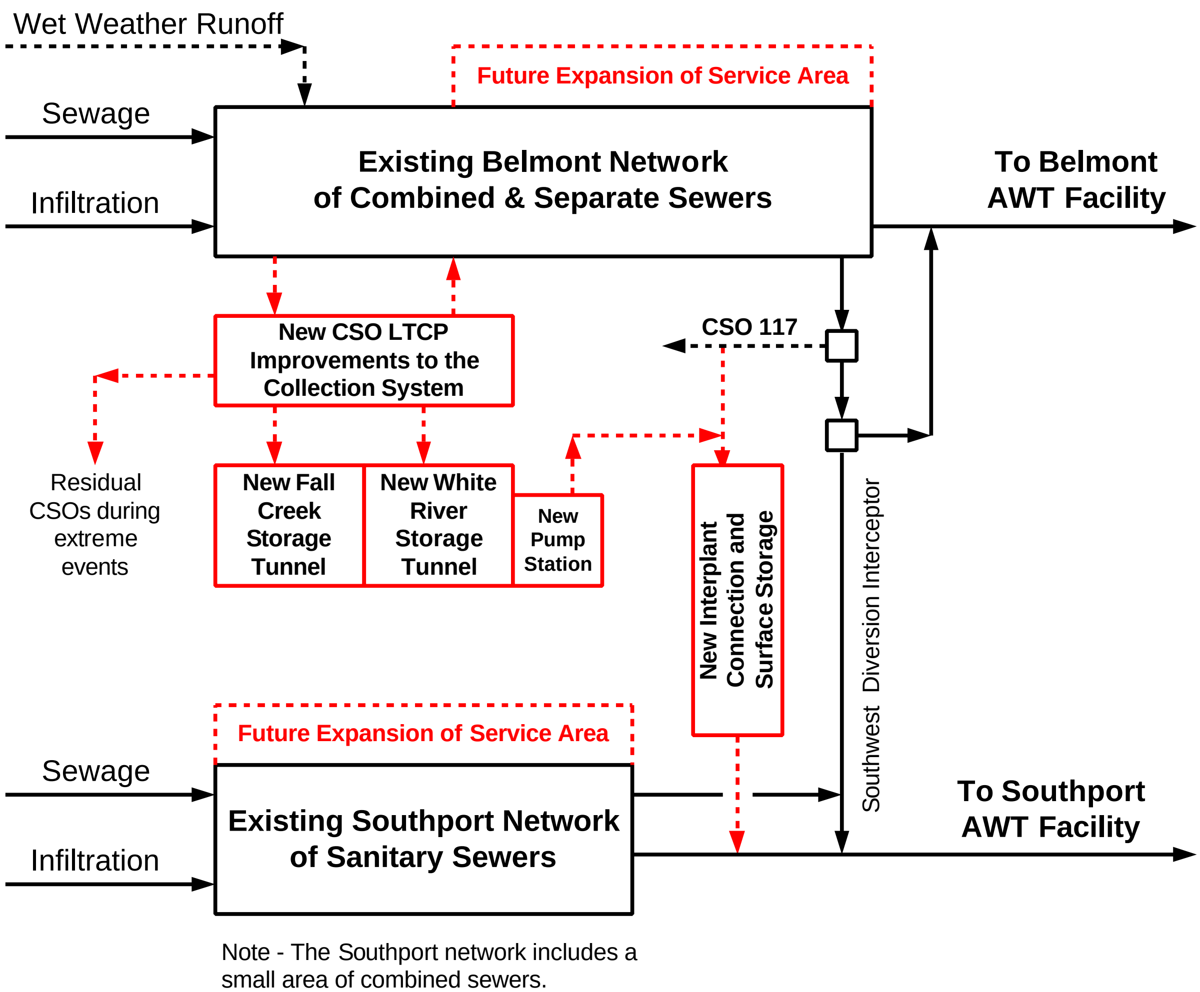


Figure ES.2
Schematic of CSO Long Term Control Plan Variant

Analysis of Dry Weather System Flows and Loads

The project team developed a 7-year database of daily data for the period 1996 through 2002. The database included the plant operating data from the monthly operating reports, precipitation data, river gauge and flow data, and sampling data for wet weather outfalls at the Belmont and Southport facilities. In a separate effort, recent master planning reports and other data were analyzed to develop estimates of how the dry weather system flowrates might increase in the future.

The following conclusions were made from these analyses:

- Monthly average dry weather flowrates for the Belmont-Southport system generally range from 125 MGD to 210 MGD and infiltration rates can be as high as 85 MGD. Infiltration in combination with inflow frequently press the two facilities into full utilization of their aggregate 250-MGD treatment capacity, especially during the months of March through June.

- Existing diversion methods enable the dry weather system flow to be split effectively between the two facilities. The new interplant connection would provide limited value during dry weather in terms of better distributing system flows.
- System-wide average flowrates are projected to increase by about 30 MGD by year 2023. Since observed flowrates to the Belmont facility have not changed over the past 27 years, only 10 MGD of the 30 MGD was allocated for the Belmont facility; the remaining 20 MGD was allocated to the Southport facility.
- Much of the allocated 10 MGD of future growth within the Belmont service area could possibly be offset by reducing the 21.5-MGD load on the Belmont headworks from in-plant return streams using techniques such as flow equalization, off-peak discharging or cascaded water reuse. Accordingly, the project team assumed that at least half of the Belmont 10 MGD flow increase would be offset in this manner and that the remaining 5 MGD of Belmont service area growth would be diverted to the Southport facility.
- Based on the foregoing, the Southport facility is projected to receive an annual average of 25 MGD of additional flow over the next 20 years, 5 MGD of which was assumed to come from the Belmont service area and 20 MGD from the Southport service area. The annual average flow of 25 MGD was translated to a peak hourly flowrate of 50 MGD using a peaking factor of 2.0. The project team believes this allocation for peak hourly flow from future growth in the service area to be conservative in relation to the peaking factor(s) apparently employed for the design of the current facilities

Results from the 5-Year NetSTORM and Tunnel Model Simulations

To determine the flow capacity the interplant connection would need for accommodating the captured CSO pumped out of the deep tunnel, the project team used captured CSO flowrates from the 5-year NetSTORM simulations as input to the integrated tunnel model, to provide the basis for an analysis of tunnel volume and dewatering rates. For a given set of input flow data, the tunnel model computed the annual average number of overflows that would occur for any combination of tunnel volume and dewatering rate assumed. For a given tunnel dewatering rate, the tunnel volume was adjusted to obtain overflow event frequencies of 1, 4, 6, 8, 12 and 16 per year.

Although the results will likely change as more rigorous assessments are made in subsequent planning efforts, the preliminary results provided the following insights regarding tunnel volume requirements:

- The tunnel volume needed to achieve relatively low overflow frequencies is significantly reduced as the tunnel dewatering rate is increased.
- The tunnel volume requirement is very sensitive to the level of CSO overflow control. For example, the results suggested that the tunnel volume needed for a control level of 1 event per year would be nearly twice that needed for a control level of 4 events per year.
- As tunnel dewatering rate is increased, a point of diminishing returns is reached where associated reductions of required tunnel volume become small. For example, the knee of the curve for 4 events per year indicated there would be no benefit for a dewatering rate higher than 150 MGD. The knee of the curve for 8 events per year indicated there would be no benefit for a dewatering flow rate higher than about 75 MGD.
- The results for tunnel volume and dewatering rate were not particularly sensitive to whether the CSO from structure 117 was diverted to the tunnel or to the interplant connection sewer. The

results also indicated there would be no benefit for the tunnel dewatering rate to be higher than 150 MGD, even for tunnel sizes projected to control overflow frequencies down to 1 events per year. Thus, it was concluded that the maximum capacity for the interplant connection line would be 150 MGD if it was to accept only the dewatering flow from the tunnel.

Although a more detailed analysis will be needed to determine the optimum tunnel volume, the results herein indicate that the tunnel volume ultimately selected for the LTCP will probably be between 100 and 300 MG.

Development and Analysis of Interplant Connection Concepts

Locating the tunnel's terminus and associated pump station near the CSO 117 area had two perceived advantages: (1) space is likely available for constructing an "EQ Basin 117" if needed; and (2) the location is suitable for splitting the tunnel dewatering flow between the Belmont and Southport facilities if desired. The potential advantages of locating the tie-in at CSO 117 were evaluated using a newly developed integrated model of the tunnel, surface storage basin and interplant connection.

In all, five concepts for the interplant connection were developed.

- **Concept 1:** Captured overflow from CSO 117 would be pumped to EQ Basin 117. The captured CSO from EQ Basin 117 and from the new Fall Creek–White River tunnel would be conveyed to the Southport facility via the new interplant connection sewer. This was the preliminary concept for the interplant connection.
- **Concept 2:** Captured CSO from Structure 117 would be sent to the deep tunnel. EQ Basin 117 would be relatively large (60 MG) and would receive the dewatering flow from the deep tunnel.
- **Concept 3:** Captured CSO from Structure 117 would be sent directly to the interplant connection, which would flow to a 275-MGD pumping station at Southport.
- **Concept 4:** Captured CSO from Structure 117 would be routed directly to the tunnel. Two versions of Concept 4 were considered that differed only in the size of the interplant connection sewer. Concept 4a assumed a 108-inch-diameter interceptor, while Concept 4b assumed a 144-inch-diameter interceptor with a substantially larger conveyance capacity. This would enable reserve capacity in the event the need later arises to send more wet-weather flow to Southport in addition to the 150 MGD of captured CSO from the tunnel. The tradeoff between Concept 4a and 4b is that Concept 4a is the lowest cost but does not allow for additional capacity. Concept 4b is most costly but has the flexibility of excess capacity.
- **Concept 5**: The Fall Creek-White River deep tunnel would be extended all the way to the Southport facility in place of constructing a conventional gravity sewer (Southport Extension Tunnel). This concept was developed based on the range of tunnel volumes resulting from the deep tunnel model. A single new pump station (150 MGD) would be located at the Southport facility to dewater the deep tunnel and convey the captured CSO to expanded Southport treatment operations.

For all five concepts, the deep tunnel system would follow Fall Creek and the White River. The deep tunnel would be about 10 miles long from its start at 42nd Street and Fall Creek to CSO 117; it would be about 5.6 miles longer if it was extended to Southport (Concept 5). The tunnel diameters examined varied from 16 feet to 31 feet. Depths varied from 120 feet to 200 feet. Tunnel dewatering rates are assumed to be 150 MGD or less. Concepts 1 through 4 included provisions for operational flexibility for splitting captured CSO between the Belmont and Southport facilities.

Figure ES.3 illustrates the five alternative concepts considered for the interplant connection. As shown in the figure, Concepts 1 through 4 included provisions for splitting captured CSO between the Belmont and Southport facilities.

Facility Sizes and Capacities

Year 2002 flow data for monitored CSO outfalls were reviewed to gain a better understanding of the importance of CSO 117 relative to other CSO outfalls. The field monitoring data showed that the annual overflow volume from CSO 117, though significant, is not especially large compared to several of the other CSO outfalls. Nevertheless, if the overflow from CSO 117 was captured and bled back to the collection system, a large equalization basin (30 MG to 60 MG) and a large pumping station (125 MGD capacity) would be needed. On the basis of the computer modeling results, the project team assumed the peak instantaneous overflow rate from CSO 117 to be 125 MGD.

The needed capacity for the interplant connection depends on whether it would be used for capturing CSO 117 alone, for conveying the tunnel dewatering flow alone, or for conveying both CSO 117 and the tunnel dewatering flow. As previously stated, the maximum dewatering rate for the tunnel would not likely exceed 150 MGD, and CSO 117 peak overflow rates would not likely exceed 125 MGD. Thus, if the interplant connection was used for conveying the tunnel dewatering flow alone, the peak capacity needed would be 150 MGD. A peak capacity of about 275 MGD would be needed if the interconnection was sized to convey both CSO 117 overflows and the tunnel dewatering, as is done in Concept 3.

A drawback to sizing the interplant connection for the combined flowrate is that it would nearly double the required capacity of the CSO treatment facility. Moreover, there would be little reason for segregating CSO 117 from the deep tunnel because, as was shown by results from the tunnel model, it has very little influence on the required tunnel volume and dewatering rate.

Concept 5 involved extending the tunnel to the Southport facility rather than building a conventional interplant connection sewer (Southport Extension Tunnel). The reasoning was that for a particular tunnel volume requirement, the incremental cost increase to build a longer tunnel of smaller diameter to the Southport facility might be offset by the savings from the avoided construction of the interplant connection sewer and a redundant pumping station. Because the tunnel volume is not yet known, the analysis considered a broad range of tunnel volumes to allow assessment of tradeoffs between terminating the tunnel near CSO 117 versus terminating it at the Southport facility.

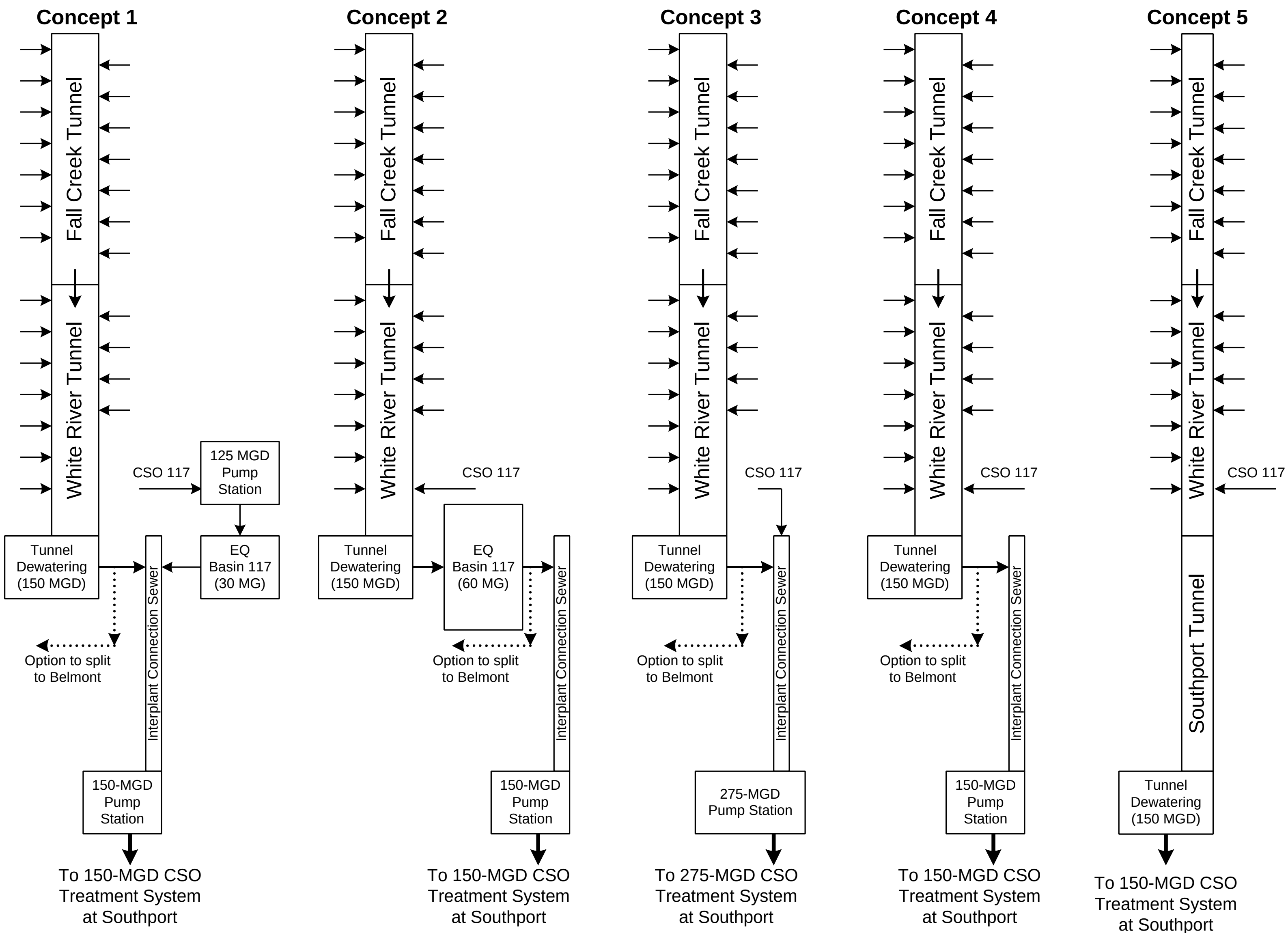


Figure ES.3
Alternative Concepts for the Interplant Connection

Routing Analysis and Conceptual Design of Interplant Connection

The physical characteristics of the land where the interplant connection sewer would be constructed were reviewed, including topography, geology, hydrology, flood hazard areas, land use, and groundwater. A schematic plan and profile for an initial route was prepared and then evaluated for technical, economical, environmental and constructability factors. Because several conflicts arose, the project team selected for detailed study a revised alignment along the selected route from the I-465 north right of way to the Southport AWT facility. Figure ES.4 shows the revised route alignment.

The Team also prepared plan and profile sheets for the preferred route using IMAGIS maps and aerial photographs. The preliminary plan and profile sheets are included in Appendix F**.**

The assumed routing of the tunnel system follows Fall Creek and the White River. The tunnel is about 10 miles long from its start at 42nd Street and Fall Creek to CSO 117. Extending the tunnel to Southport for Concept 5 would increase its length by another 5.6 miles (Southport Extension Tunnel). From the start, the tunnel alignment follows Fall Creek to I-65, to West Street, to Kentucky Avenue, to White River, and to Harding Street. At the intersection of Harding and Hanna Avenue, the tunnel turns southwest to the intersection of I-465 and the White River. It then follows the White River south to Southport AWT. The tunnel diameters examined varied from 16 feet to 31 feet. Depths varied from 120 feet to 200 feet.

Development of Cost Estimates

Cost estimates were developed using procedures intended to provide sufficient level of detail to support facility planning level comparisons of alternative project approaches.

Construction cost estimates for the interplant connection considered new reinforced concrete pipe (RCP) sewer construction and water grade prestressed concrete pipe (PCP). The estimates included costs for excavation, sheeting and bracing, haul, fill, compaction, and disposal of excavation material. Costs for manholes and appurtenances were added by means of site- and project-specific factors. Pavement restoration, traffic routing and extensive dewatering were also covered by these adjustment factors. Figure ES.5 shows costs for constructing the interplant connection interceptor alternatives using Class IV PVC lined RCP and lined water grade PCP.

Construction cost estimates for the deep tunnel were based on project experience from areas including Milwaukee, Cleveland and Chicago. While the rock conditions in Indianapolis have not yet been sufficiently defined, initial assessments indicate geology at the intended tunneling depth to be sedimentary dolomite, limestone and shale formations. Costs represent a complete tunnel in place, but without deep pump stations. Costs not included, but that may be applicable based upon project specific

Figure ES.4
Proposed Routing of the Interplant Connection

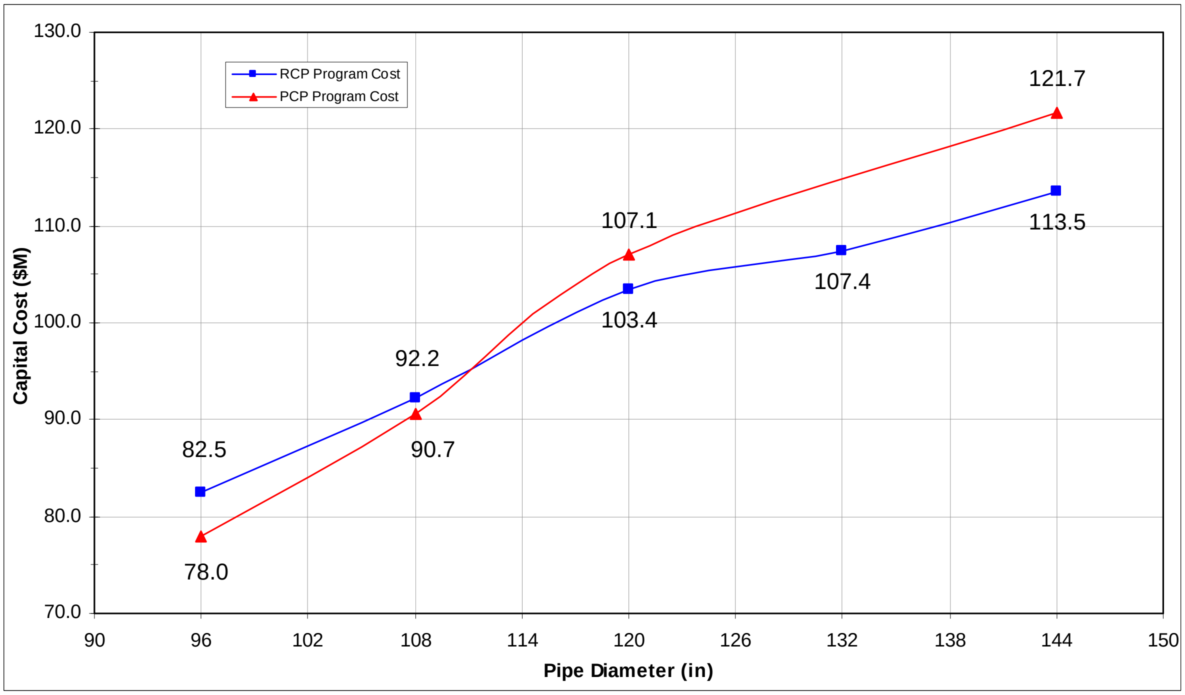


Figure ES.5
Capital Cost Curves for the Interplant Connection Sewer

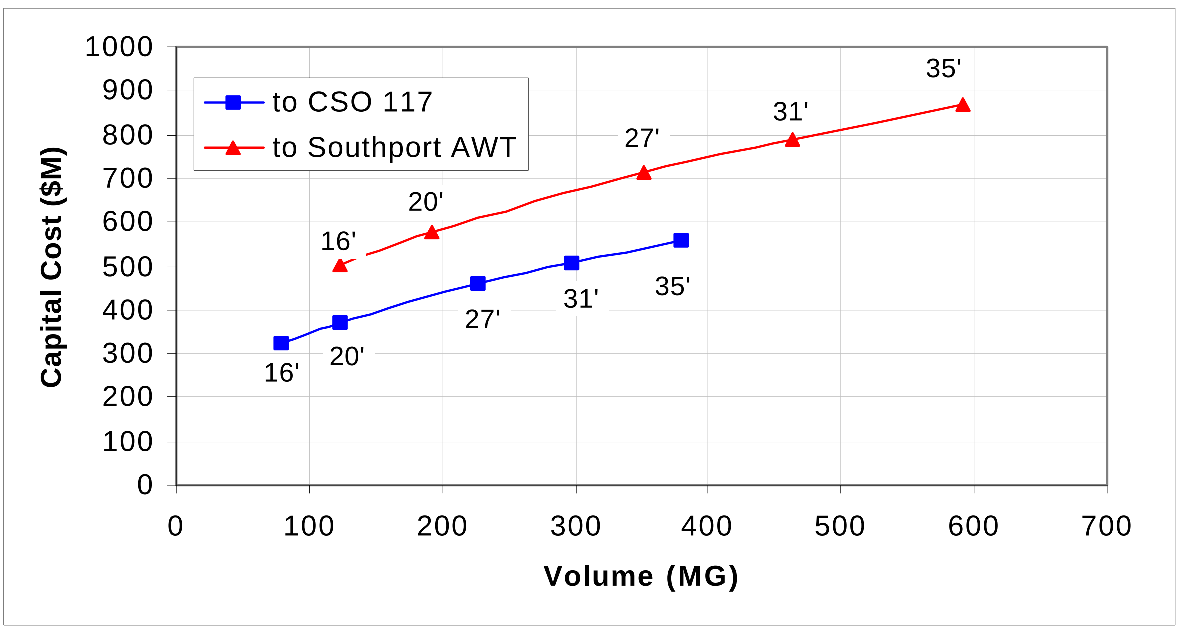


Figure ES.6
Capital Cost Curves for Overall Tunnel System

refinements, include excess dewatering, utility relocation, boulder zone, and pavement restoration. Odor control facilities are not included. All tunnel costs assume tunneling in good rock, limited groundwater, no grouting, no ground gasses and an open faced tunnel boring machine. Figure ES.6 shows the costs for constructing a single deep tunnel, in a wide range of tunnel volumes, terminating at CSO 117 and at the Southport facility.

Cost Comparison of Alternatives

Estimates of probable capital and operating costs were developed for Concepts 1 through 5. To provide a common basis of comparison, the costs included the overall tunnel, rather than just the extension from CSO 117 to Southport. The cost estimates were developed over a range of tunnel volumes to see if future decisions regarding the tunnel volume requirements would affect which concept was preferred for the interplant connection. Figure ES.7 shows the results from the capital cost comparisons. Results from present worth cost comparisons showed similar trends.

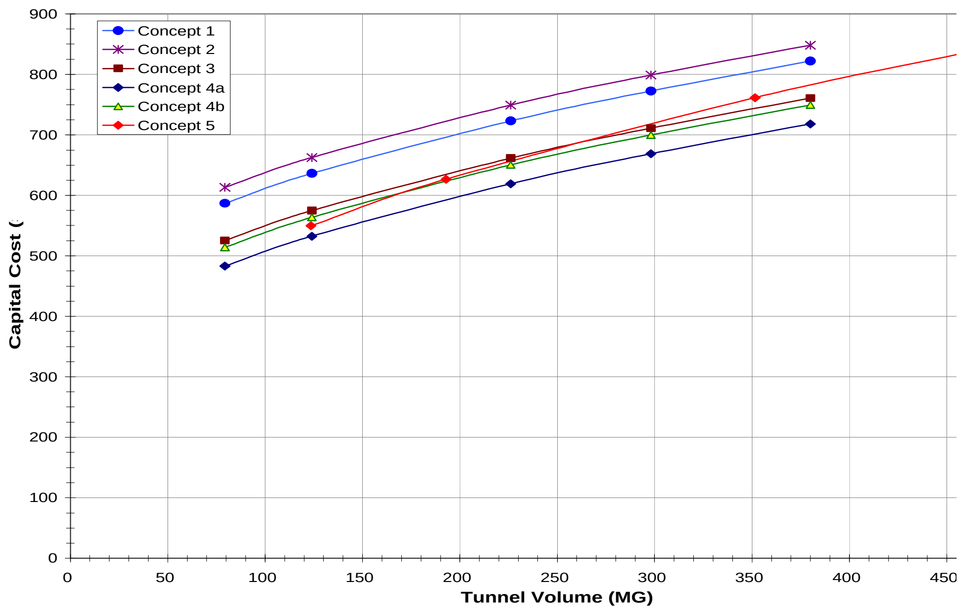


Figure ES.7

Capital Cost Comparison of Interplant Connection Concepts

Conclusions

The following conclusions were drawn from the cost comparative analyses:

- Concept 1 was screened out because of overall cost and complexity. A complex system of pumping and equalization would be required to simply capture CSO 117. In addition, tunnel volume would not be significantly reduced.
- Concept 2 was also screened out because overall cost and complexity. The capital cost for a 60-MGD EQ Basin 117 would provide limited benefits as the basin would have limited effect on reducing either the capacity of the CSO treatment system or the tunnel volume.
- Concept 3 was screened out because it would require a sewer capacity of 275 MGD compared to only 150 MGD. More importantly, it would require a 275-MGD CSO treatment system rather than a 150-MGD CSO treatment system.

- Concepts 4a and 4b both met the project criteria and were among the least expensive options. Figure ES.7 suggests that Concept 4a is the least cost alternative, however, it doesn't provide capacity above the proposed tunnel dewatering rate.
- Concept 5 was screened out because (1) the uncertainty as to whether existing underground stone quarries between Belmont and Southport would physically block the likely routing; (2) long delays in implementing the interplant connection because it would be tied in with the rest of the deep tunnel project; (3) limited operational flexibility; and (4) relatively little likelihood that the concept would cost less than the conventional methods of Concepts 4a and 4b.

The project criteria was satisfied by both Concept 4a and 4b, with 4a having the lower cost. However, considering the resulting benefit of reserve capacity, the project team and DPW agreed that Concept 4b would be moved forward into design. If no major construction issues develop during the detailed design phase related to the increased diameter, construction of 4b will proceed. The probable capital cost for the 144-inch-diameter interplant connection, excluding the pumping station needed at the Southport facility, is estimated to be $122 million.

Analysis of Options for Splitting the Captured CSO

An issue that arose during the project was whether part of the captured CSO should be sent to the Belmont facility or whether it should all be sent to the Southport facility. The issue was addressed by evaluating, via computer simulations, what would have happened had the tunnel and flow-splitting provisions been in place during the 5-year period from 1996 through 2000.

In one simulation, the flow was split at a 60-MG EQ Basin 117. The results showed, however, that EQ Basin 117 would serve limited effective purpose either in the near term or the long term for CSO abatement. It would not effectively reduce flow surges imposed on the plants from the tunnel dewatering station. The basin would also raise another process concern that equalization storage in addition to that planned for the two facilities might lead to undesirable cooling in the winter, thereby making treatment in the AWT facilities more difficult.

The results also showed that attempting to split the tunnel flow to the Belmont facility would be limited, because an expanded Belmont facility would have limited reserve capacity to treat part of the captured CSO from the tunnel. A related result was that provisions for splitting part of the flow to the Belmont facility would not reduce the cost of improvements needed at Southport for treatment of CSO. This is because the full 150 MGD rate of tunnel dewatering would frequently be imposed on the Southport facility regardless of efforts to split part of the CSO load to Belmont. Based on this analysis the project team's recommendation is to route the full amount of captured CSO flow to the Southport facility.

Supplemental Analyses using the SWMM Combined Sewer Model

To confirm the tunnel evaluations, the project team performed single-event design storm simulations and continuous simulations using the more detailed SWMM.

Single Event Simulations

Single-event simulations were performed for six storage tunnel and interplant connection configurations using a control level of four overflows per year. The configurations considered terminating the tunnel at CSO 117 or at Southport; and discharging CSO 117 to the tunnel or to the interplant connection. It also considered conveying CSO 008 to the tunnel. All simulations were evaluated with a 3-month Soil Conservation Service (SCS) design storm with the tunnel dewatering rate set at 150 MGD and the tunnel volume set at 350 MG (the maximum projected from the 5-year NetSTORM runs). Depending on the particular scenario, the dewatering period ranged from 24 hours to 36 hours. The CSO 117 peak overflow rate was about 80 MGD and was consistent with field flow monitoring results. As expected, the accumulated volume in the tunnel was much larger when CSO 008 was included in the capture.

Continuous Simulations

To facilitate continuous SWMM modeling analyses of the Indianapolis sewer system, the project team examined local precipitation data to identify a representative year for use in model simulations. Digital hourly data for rainfall at the Indianapolis International Airport for the period of 1951 through 2000 was used as the primary source for establishing precipitation and runoff norms. Hourly data for the city's rain gauging program for the period of 1996 through 2000 was also reviewed. After extensive analysis, the project team selected 1959 as the representative year for SWMM continuous simulation.

The configuration used for continuous simulations for precipitation year 1959 assumed the tunnel terminus at CSO 117 and that the tunnel captured CSO outfalls 117 and 008. Simulations were performed using CSO control levels of both 12 and 4 overflows per year. The results from the continuous SWMM simulations confirmed that the upper limit of storage tunnel sizes (about 350 MG) derived from the 5-year NetSTORM model would have been adequate for the precipitation year 1959.

Next Steps for Tunnel Optimization

A significant degree of uncertainty exists as to the optimum volume for the tunnel due to the state of the CSO LTCP. For example, the volume could range from about 100 MG to 300 MG for a 6 event per year frequency. Figure ES.8 shows CSO event frequency vs. tunnel volume requirements derived from various models, scenarios and representative periods.

As an integral part of the final CSO LTCP, the project team recommends the uncertainty in the methods for estimating tunnel volume be resolved. Specific approaches include the following:

- Validate the adjustment of antecedent moisture conditions made for the 5-year NetSTORM model. This can be done by performing continuous SWMM simulations for a multiyear representative precipitation period. Logically, this would match the same 5-year period used for NetSTORM (1996 through 2000). More recent periods could also be selected.
- Use spatially varied rainfall data to enhance the model input and therefore improve the accuracy of the model results. Precipitation data is the key input to the hydraulic modeling tools. The 5-year NetSTORM model made use of the city's data to the best practical extent.
- If necessary, further confirm the SWMM model accuracy in accounting for antecedent conditions through ongoing work on CSO discharge monitoring reports.
- Optimize the tunnel using the representative precipitation period/year analysis with spatially varied precipitation data where available.

The storage tunnel optimization analysis may result in a smaller range of tunnel volumes and dewatering rates to be recommended in the final CSO LTCP.

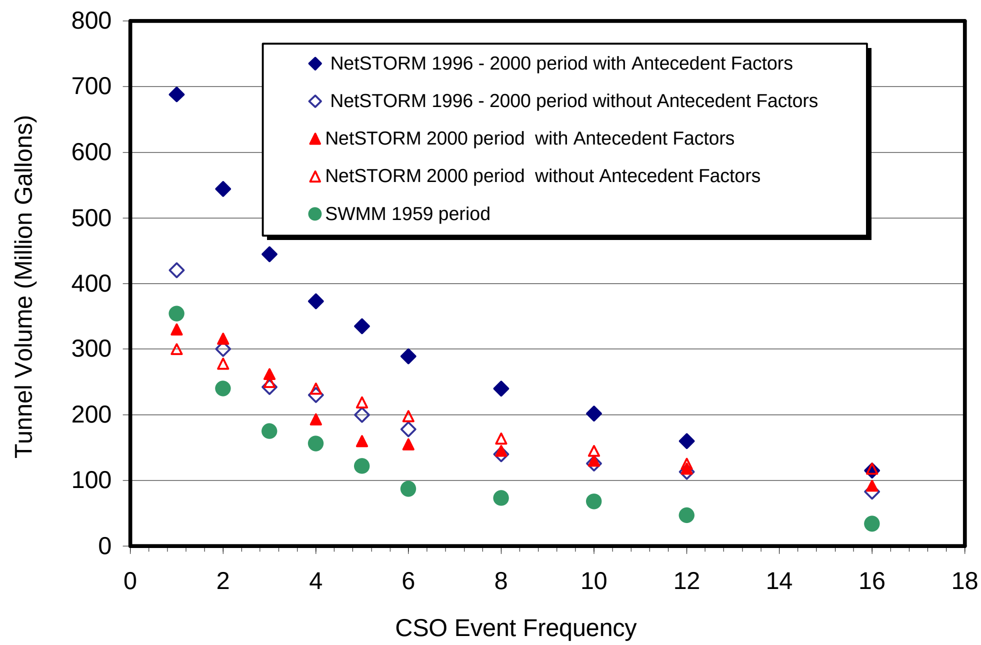


Figure ES.8
Probable Range of Tunnel Volumes Needed to Achieve Various Levels of CSO Control

Review of Existing Southport AWT Facility

The Southport AWT facility has a design average flow capacity of 125 MGD and a design peak flow capacity of 150 MGD. In round numbers, about a third of the Southport dry weather flow is from the combined sewer service area. Several improvements will be implemented in the near term.

As the city has progressed toward developing an approved plan for abating CSOs, it has become clear that the Southport facility must play an even greater role in relieving the Belmont collection system from the burden of CSO. The Southport facility could ultimately be called upon to treat captured CSO at rates equivalent to the current peak capacity of the facility (150 MGD). The project team therefore considered strategies for essentially doubling the rate at which wastewater can effectively be treated at the Southport facility.

To generate ideas for expanding the Southport facility, the project team conducted a process analysis of the existing treatment operations. Insights gained during the process analysis included the following:

- The process flowsheet for the Southport AWT facility is very complex and awkward because of the interchanges between the older air activated sludge nitrification process (ANS) and the newer oxygen activated sludge nitrification system (ONS). In addition, there are three types of biological processes to operate (ANS, bio-roughing towers [BRS] and ONS). Future improvements to the facility should strive to simplify the process flowsheet.
- Wet weather overflows and/or bypasses occur at the Southport facility about eight times per year. A planned 75-MGD headworks pump station and 25-MG wet weather flow storage basin will significantly attenuate these overflows and may enable the peak flow capacity of the Southwest Diversion (Southern Avenue) Interceptor to be used more extensively during wet weather flow conditions.

- The ability of the Southport facility to relieve Belmont from part of the CSO burden is poor during the late winter and early spring when infiltration rates are highest.
- As expected during wet weather flow conditions, the peak daily effluent flowrates currently reach the 150-MGD design capacity for the overall facility. In addition, the facility design average flowrate of 125 MGD is reached or exceeded several times per year, undoubtedly as a result of maximizing treatment of wet weather flows during periods of high groundwater infiltration.
- Raw sewage loads for biological oxygen demand (BOD), total suspended solids (TSS) and ammonia as nitrogen (ammonia-N) are generally within the original design criteria of the facility. Critical challenges to resolve include the high TSS load imposed on the Southport facility when the Belmont gravity diversion line is used; and extremely high soluble BOD loads caused by deicer wastes from the Indianapolis airport.
- Although the primary clarifiers seem to function reasonably well, they are nearly 40 years old, are too shallow to meet current design standards, and currently have no reserve capacity to treat flowrates in excess of 150 MGD.
- The bio-roughing towers appear to be functioning properly and within the acceptable hydraulic and organic loads.
- The ONS could recoup about 10 MGD of allocated flow capacity if the tertiary filtration backwash and other in-plant return streams were dealt with in some other fashion. Methods to consider include a dedicated flow equalization tank and/or treatment in the ANS.
- The aggregate aeration tank volume of the ANS is about 25 percent larger than that for ONS: 20.2 MG versus 16.2 MG. However, the ANS clarifiers are only about 28 percent the size of the ONS clarifiers and are very shallow. Thus the effective capacity of the ANS is severely limited due to undersized clarifiers.
- The BOD and TSS loads imposed on the ONS sometimes exceed the design criteria. Fortunately, the ONS design criteria were conservative so that performance to date has been reliable, even though the ONS has been operating on air rather than oxygen. Because of the conservative sizing of the ONS final clarifiers and demonstrated performance of the overall system, consideration should be given to revising the rated capacity of ONS upward.

CSO Treatment Alternatives for the Southport Facility

The project team has concluded that the full amount of captured CSO should be conveyed to the Southport facility. This was, in part, because (1) wet weather capacity for sharing the load would seldom be available at the Belmont facility; (2) options for treating additional wet weather flow at Belmont would be very limited; and (3) treatment and permitting requirements at a new location would be very challenging. Also, the Southport facility offers many possibilities including space for consolidated treatment of the captured CSO. Alternative concepts were therefore developed and evaluated for expanding and upgrading the Southport facility for treating current wet weather flow surges, captured CSO from the future tunnel, and additional dry weather flow from future growth within the service area.

Tunnel Dewatering Flow Patterns

As was concluded earlier, the tunnel dewatering rate is expected to be no higher than 150 MGD. The flow pattern from one event to another will be extremely variable depending on the durations and intensities of the precipitation events. Figure ES.9 shows the results from a statistical analysis of dewatering events from the tunnel dewatering model. For this analysis, the tunnel dewatering rate was set to 150 MGD, and the volume at which the dewatering pumps were activated was set at 25 MG. The model included a feature whereby the dewatering pumps would turn on at a volume less than 25 MG if the event volume was less than 25 MG. Based on the results shown in Figure ES.9, over 55 percent of the 62 annual dewatering events had volumes less than 25 MG. A drawback of a standalone CSO treatment process would thus be the frequency of starting up a large-scale facility to treat only a small volume of captured CSO. A better concept would be to design the mainstream wastewater treatment process for absorbing the smaller events in a straightforward manner.

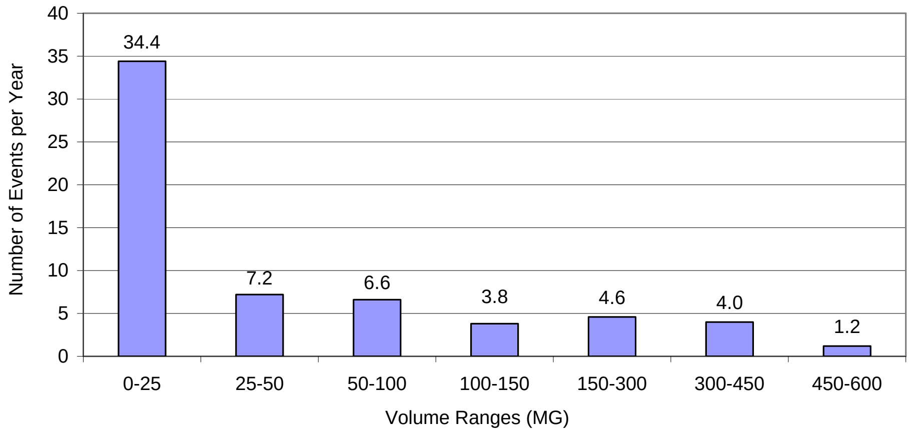


Figure ES.9

Ranges of Tunnel Dewatering Volumes for Assumed Operating Strategy

Estimates of Pollutant Loads from Captured CSO

The development of appropriate CSO treatment options requires a basic understanding of the concentrations of conventional pollutants (BOD, TSS and ammonia-N) and how they vary in response to types of precipitation events and antecedent weather conditions.

A high degree of variability in TSS concentrations is expected because solids deposited in the sewer during the low-flow periods get flushed out during wet weather periods when flow velocities are high. Based on a review of available CSO sampling data from the Indianapolis facilities and data reported in the CSO technical literature for several other communities, the flow-weighted average TSS concentration in the captured CSO discharged from the tunnel was assumed to be about 300 milligrams per liter (mg/L). Because peak suspended solids concentrations of 2,000 mg/L or higher will likely occur for some events, the CSO treatment process will need to include conventional primary settling or conventional secondary settling for bulk suspended solids removal and storage along with appropriate provisions for screening and aerated grit removal.

To estimate pollutant loads of ammonia-N and soluble BOD, the project team reviewed and summarized CSO sampling data from the Belmont headworks, the Southport headworks and CSO 117. As expected, the concentrations of ammonia-N and soluble BOD in CSO are much lower than in dry weather flow because of dilution. The dry weather average amounts of ammonia-N and soluble BOD in the raw sewage were used as the basis for computing the diluted concentrations in the captured CSO. The flow-weighted averages for the tunnel discharges from the 5-year tunnel simulation model were as follows:

- 4.9 billion gallons captured CSO per year
- 10 mg/L soluble BOD
- 2.6 mg/L ammonia-N

Assessment of Need to Remove Ammonia-N and/or Soluble BOD

Estimates of the effluent quality that would result from blending captured CSO with AWT effluent indicated that ammonia-removal would not be necessary to comply with the current weekly average and monthly average permit requirements. The same conclusion also held true for soluble BOD. However, the soluble BOD load would be of concern, in part because of the traditional impact on dissolved oxygen depletion, but also the concern of capacity to meet future discharge requirements. Thus the project team concluded that CSO treatment at the Indianapolis facilities should include, to the extent practical, effective removal of the soluble BOD from the captured CSO.

Development of Southport Facility Design Flowrates

The analysis of system flowrates indicated the plan for headworks pumping and preliminary treatment (screening and aerated grit removal) will need to accommodate an average flowrate of 125 MGD and a peak hourly flowrate of at least 425 MGD. This requirement includes provisions for future growth in the service area (25 MGD average and 50 MGD peak); up to 150 MGD of captured CSO from the tunnel system; continuous diversion of about 25 MGD from the Belmont headworks; and a 25 MGD safety factor for existing peak flows.

Were it not for the 150 MGD flowrate of captured CSO from the tunnel, the future treatment rate requirements for the Southport facility would be an average flow of 125 MGD and a peak hourly flow of 225 MGD (75 MGD higher than the current capacity). Table ES.1 compares the current and future design flow requirements for this plan.

Table ES.1
Comparison of Current and Future Design Treatment Flowrates

Treatment Capacity	Current Oxygen Nitrification Process	Current Air Nitrification Process	Total Current Capacity	Future (excluding CSO from Tunnel)	Future (including CSO from Tunnel)[1]
Design average	95 MGD	30 MGD	125 MGD	125 MGD	n/a
Peak hourly	120 MGD	30 MGD	150 MGD	225 MGD	375 MGD

[1]The criteria for future treatment rates assume a 25-MG storage basin and 425 MGD of headworks pumping capacity, 150 MGD of which is from tunnel dewatering

Alternative Concepts for Southport Wet Weather Expansion

In all, four concepts for achieving an additional 225 MGD of treatment were developed. Concepts 1 through 3 were developed initially; Concept 4 was developed using the best features of the other three. Each concept was as follows:

- **Concept 1**: Retrofit the ANS to provide 75 MGD of biological treatment and construct a 150-MGD physical-chemical process to treat the captured CSO.
- **Concept 2**: Retrofit the ANS to provide 150 MGD of biological treatment and construct a 75 MGD expansion of the ONS.
- **Concept 3**: Retrofit the ANS to provide 225 MGD of biological treatment.
- **Concept 4**: Retrofit the ANS to provide 150 MGD of biological treatment (including half of the 150 MGD of captured CSO) and construct a 75-MGD physical-chemical process for treatment of the more dilute half of the captured CSO. This 75 MGD remainder would be treated using a enhanced high rate clarification (EHRC) treatment process for efficient removal of suspended

matter. This process would be operated intermittently and thus needs to be preceded by a 15-MG holding basin to enable smooth startup.

The concepts were evaluated by a screening analysis that compared the following nine criteria:

- Effluent quality
- Ease of operation
- Sludge processing
- Compatibility with existing equipment
- In-plant recycle streams
- Energy
- Expandability
- Adaptability to future requirements
- Capital costs

Concept 4 was at or near the top for all of the criteria considered and was clearly the preferred concept. The project team thus recommended that Concept 4 be adopted as the basis for expanding the Southport facility in accordance with the LTCP.

Recommended Plan for the Southport Facility

The recommended plan for expanding the Southport facility is as follows:

- Plan an all new headworks, including screening and aerated grit removal. This recommendation is based on the nearly three-fold increase in capacity and the importance of a blended raw wastewater for downstream process reliability. However, the portion of the captured CSO that is treated by EHRC must be segregated from the mainstream to assure effluent soluble BOD remains low.
- Retain the existing primary clarifiers, but supplement them with new primary clarifiers conservatively designed to treat a peak hourly flow of 275 MGD and an average flow of 125 MGD. This sizing allows for one of the existing cluster of ANS primary clarifiers to be occasionally out of service. The existing primary clarifiers would generally be on line all the time at a relatively low flow in readiness for treating wet weather surges up to 150 MGD. Including 75 MGD of primary treatment recommended for the EHRC process, the overall primary treatment capacity with all units in operation would be 500 MGD.
- Retrofit the existing 30-MGD ANS to provide 150 MGD of aggressive biological treatment during peak wet weather flow periods, including efficient nitrification at flows up to about 120 MGD. The existing aeration tanks would be fitted with new fine bubble air diffusers and the aeration blowers would be replaced or supplemented as needed. The existing ANS final clarifiers would be replaced with larger circular or rectangular units having a peak capacity of 150 MG. The surface area requirement is 125,000 square feet.
- Leave the existing ONS intact, but revise the rated capacity upward to 100 MGD average (compared to 95 MGD average) and 150 MGD peak (compared to 125 MGD). The basis of the improved rating would be demonstrated performance, upgraded primary clarification to reduce the solids loading, recognized design criteria, and elimination of flows imposed on the ONS from filter backwashing.

Figures ES.10 and ES.11 show the process flowsheet and general layout, respectively, for the recommended concept.

The planned 75-MGD wet weather pump station and 25 MG wet weather holding basins for flow equalization would reduce by 50 MGD the peak hourly flow through the headworks, preliminary treatment and primary treatment. The peak flowrates imposed on downstream biological facilities would thus be 300 MGD.

Collectively, the improvements to ANS and ONS would enable up to 300 MGD of effective biological treatment at the Southport facility, thereby doubling the current 150 MGD capacity. The flow sheet would be relatively simple to operate, and the system would enable flow surges from over half of the captured CSO events to be absorbed in the mainstream plant without special provisions for starting up additional process equipment.

The design average flow capacity for biological nitrification would increase to 150 MGD, even though the design requirement would be only 125 MGD average. Thus there would be a built in safety factor of 25 MGD for future growth in addition to the 25 MGD allocated over the next 20 years.

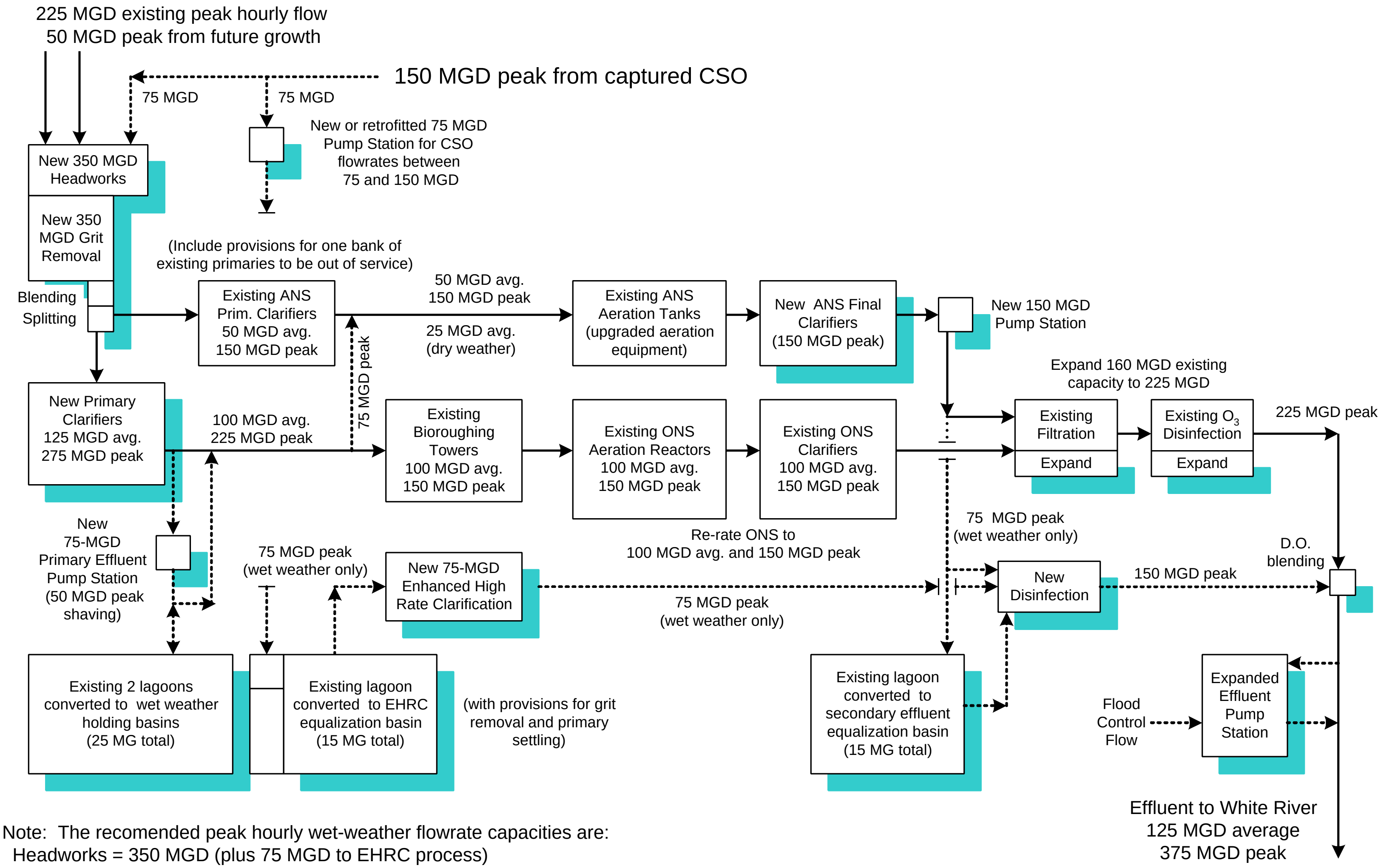
The project team's recommended plan for biological treatment would satisfy all but 75 MGD of the 375-MGD peak treatment rate. This 75 MGD remainder is the second half of the captured CSO in excess of the 75-MGD treated biologically and would be treated using EHRC or its equivalent. Because this process would be operated intermittently, it needs to be preceded by a 15-MG holding basin to enable smooth startup. The basin should be fitted with preliminary treatment equipment such as swirl concentrators to remove grit, heavy solids and floatables. Installation of a 75-MGD primary settling basin within or adjacent to holding basin is also recommended. The final sizing of the EHRC process depends on the needed tunnel volume and the captured CSO dewatering rate. If the captured CSO dewatering rate is 75 MGD rather than the 150 MGD rate assumed herein, then the EHRC process would not be needed.

Table ES.2 summarizes planning level cost estimates for the components of the recommended concept.

Table ES.2
Partial Estimate of Probable Costs for Expanding the Southport Facility to 375 MGD Peak Capacity

Component	Cost
Raw wastewater (captured CSO) pump station for EHRC (75-MGD firm capacity)	$13,090,000
New 350-MGD headworks facility w/ screening	$45,440,000
New 350-MGD grit removal facility with blending and flow split	$13,680,000
New 125-MGD/275-MGD primary clarifiers (125,000 sf)	$51,850,000
New 75-MGD wet weather pump station - awarded	NA
New wet weather holding basins (25 MG total) - awarded	NA
New 15-MG EHRC basin w/ grit removal and primary settling	$6,750,000
New 75-MGD EHRC facility	$22,080,000
New ANS aeration equipment	$7,970,000
New ANS return activated sludge pumping	$5,904,000
New ANS final clarifiers (8 units each @ 155’ diameter)	$54,751,400
New effluent pump station on ANS (150-MGD firm capacity)	$6,040,000
New 15-MG secondary effluent equalization basin w/ aerators	$5,640,000
Expansion of existing filtration process to 225 MGD	$10,360,000
Ozone disinfection expansion	NA
Supplemental disinfection process (chlorination/dechlorination)	$6,510,000
Expanded/upgraded effluent pump station as needed (568-MGD firm capacity)	NA
Yard piping and valves	$8,990,000
Construction Cost Estimate Partial Total	**$259,060,000**

NA – Not Applicable. For purposes of discussion, these have been listed, but are not considered part of the interplant connection.



Note: The recomended peak hourly wet-weather flowrate capacities are:
- Headworks = 350 MGD (plus 75 MGD to EHRC process)
- Preliminary & Primary Treatment = 350 MGD (with one ANS bank out)
- Peak Flow Reduction by Equalization = 50 MGD
- Biological Nitrification = 225 - 300 MGD (300 MGD firm Act. Sludge Treat.)
- Filtration = 225 MGD (excludes 150 MGD captured CSO)
- Enhanced High Rate Clarification = 75 MGD
- Plant Effluent Peak Discharge Rate = 375 MGD
- Plant Effluent Design Average Discharge Rate = 125 MGD

Figure ES.10
Schematic of Recommended Long Term Plan for Southport Facility Expansion and CSO Treatment
(Retrofit ANS to 150 MGD biological treatment and construct new 75-MGD enhanced high-rate clarification process)

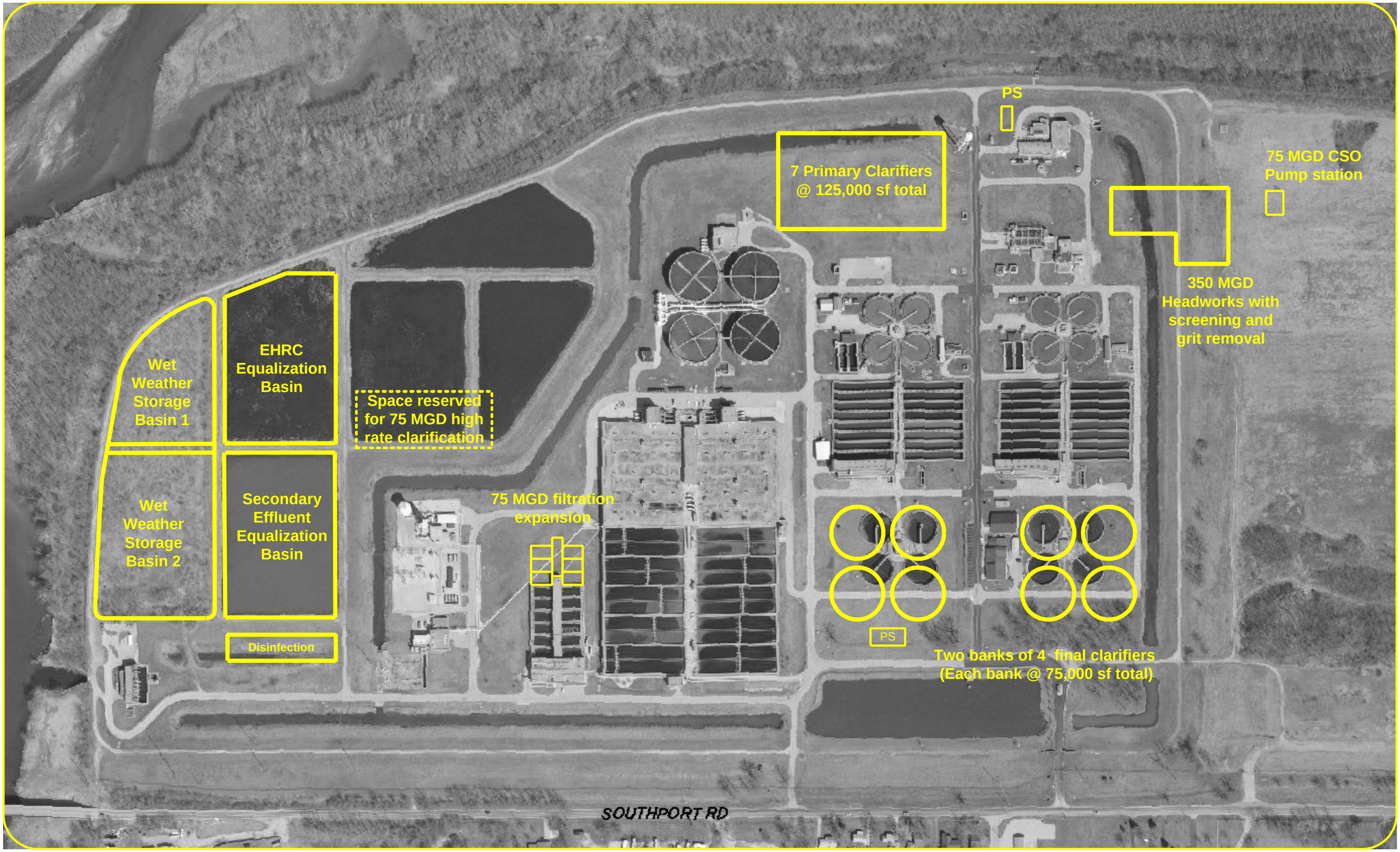


Figure ES.11

Conceptual Layout of Recommended Long Term Plan for Southport Facility Expansion and CSO Treatment